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Aldrin, heptachlor and β-hexachlorocyclohexane to dairy cows at three oral dosages. 2. Residues post partum in milk and body fat of cows fed on pesticides in the dry period*

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Summary

During the whole dry period 3 groups of 3 Dutch Black Pied and Meuse-Rhine-IJssel cows each, in a preceding trial also dosed with pesticides during late lactation, received 3 levels each of aldrin, heptachlor and β-HCH together with concentrate: 0.5 mg, 1.0 mg or 2.0 mg per cow daily.

Body fat and milk fat samples after calving were taken and analysed for pesticide content.

Aldrin and heptachlor were below the detection limit of 0.01 mg/kg fat. Contents of β-heptachlorepoxide were in the most cases below 0.1 mg/kg, even for the highest dosage.

For β-HCH and dieldrin in milk fat a fairly good agreement was found between adjusted values just after calving and values for cows early and late in lactation, both at the end of the dosing period.

A considerable variation in pesticide content of body fat was found, particularly for dieldrin in cows with the highest dosage.

A derivation of maximum tolerable content of pesticide in feed in the dry period is given by using accumulation coefficients and transfer coefficients. The results of both calculation methods agree very well and are compared with legal tolerances for feed.

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Introduction

Transfer of organochlorine pesticides and their metabolites from feed into milk and body fat of dairy cows has often been studied in an earlier or later stage of lactation (Kölling, 1974; Vreman et al., 1976). Also in the dry period, dairy cows and ingest persistent organochlorine pesticides, for example, with roughage or concentrates. Because of the absence of milk production then pesticides can accumulate in the body fat of cows. This may result in a higher contamination of milk than by exposure to the pesticide during lactation (Miller, 1967; Whiting et al., 1973). The present study investigated how far oral administration of aldrin (1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-*exo*-1,4-*endo*-5,8-dimethanonaphthalene), heptachlor (1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene) and β-hexachlorocyclohexane (β-HCH, β isomer of 1,2,3,4,5,6-hexachlorocyclohexane) in the dry period causes accumulation in body fat and contamination of milk fat immediately after calving and during the first weeks of lactation.

Materials and methods

During the whole period of about 8 weeks, 3 groups of 3 Dutch Black Pied and Meuse-Rhine-IJssel cows each, in a preceding trial also dosed with pesticides during late lactation (Vreman et al., 1976), received 3 levels of aldrin, heptachlor and β-HCH together with concentrate.

The dosages per cow were 0.5, 1.0 and 2.0 mg per day of each pesticide for

Table 1. Summary of experimental conditions.

Group →	1	2	3
Number of cows →	3	3	3
Body weight (kg)			
– just after calving, mean	649	570	559
range	630–667	570–582	502–608
– 1 month after calving, mean	599	532	528
range	594–603	513–567	482–564
Milk fat production (g/day), mean	1060	1159	891
range	971–1129	1124–1185	815–951
Intake of hay (kg/day)			
– dry period	8	8	8
– first 5 weeks after parturition	7	7	7
Content of dry matter in hay (%)	87	87	87
Intake of concentrate (kg/day)			
– dry period	1	1	1
– first 5 weeks after parturition	9	10	8.5
Content of dry matter in concentrate (%)	87	87	87
Dosage of each pesticide (mg/day)	0.5	1.0	2.0
Total dose of each pesticide (mg)			
– mean	26	56	87
– range	22–29	46–61	50–130

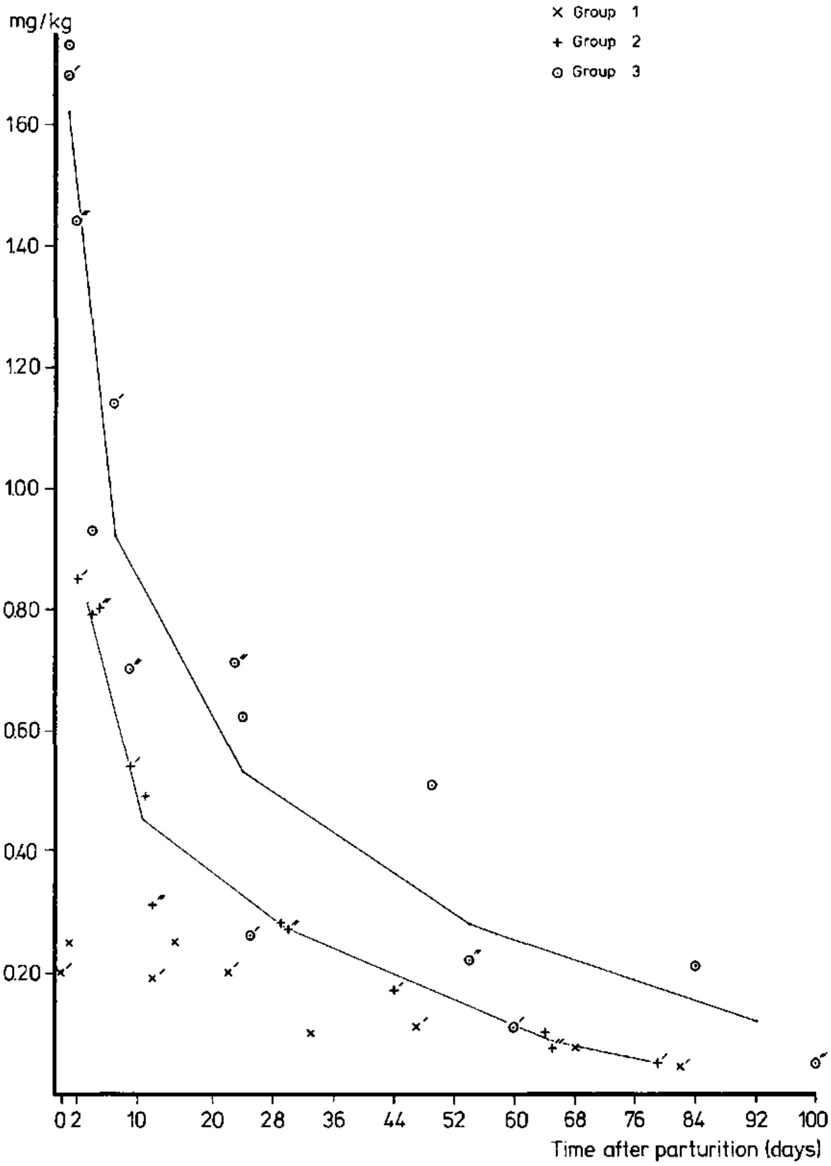

Fig. 1. Content of β-HCH in milk fat of cows given three levels. (The three cows of each group are distinguished by accents over the data points.)

Groups 1, 2, and 3, respectively. At parturition, administration of pesticides was terminated. Because the date of parturition could only roughly be predicted, the dry period per cow varied considerably, resulting in large differences in total dose of pesticides for cows within a group (Table 1).

After calving, milk yield was recorded weekly on 3 consecutive days for 5 weeks.
Dosing method, sampling of milk for estimation of fat and pesticide, and analytical methods were as described before (Vreman et al., 1976). Samples of subcutaneous body fat from the flank of all cows were taken on 18 February 1975 close to calving and 5 weeks later.

Because of variation in the real date of calving between cows, the date of taking a biopsy sample is expressed as number of days after parturition (minus means before). The first date of sampling ranged from 9 days before parturition for the second cow of Group 3 to 15 days after parturition for the first cow of Group 3.
Details of the cows, of the rations and of the pesticides are summarized in Table 1.

Results and discussion

Milk fat

Contents of β-HCH and dieldrin in milk fat are shown in Fig. 1 and 2. Aldrin and

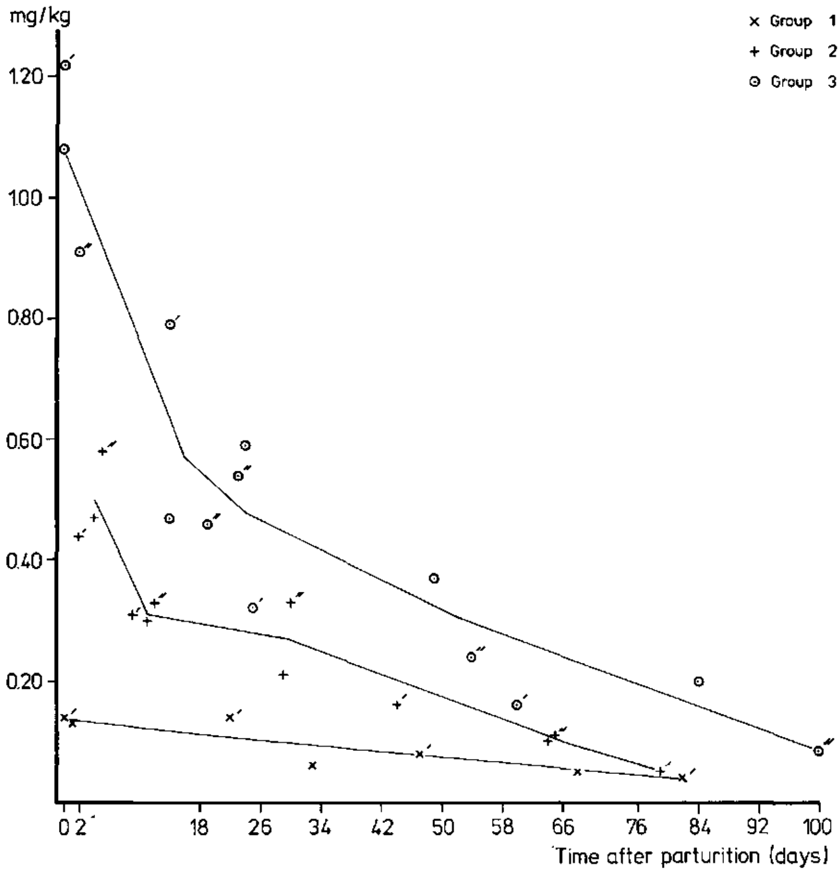

Fig. 2. Content of dieldrin in milk fat of cows given three levels.

Table 2. Average contents of β-HCH and dieldrin in mg/kg in milk fat and body fat at the end of the dosing period of cows late and early in lactation (data from Part 1) and just after calving. For explanation of adjusted value see text.

	β-HCH			Dieldrin		
Group →	1	2	3	1	2	3
In milk fat						
– early in lactation	0.34	0.67	1.18	0.28	0.48	0.80
– late in lactation	0.28	0.58	1.05	0.22	0.50	0.99
– just after calving	0.23	0.81	1.62	0.14	0.50	1.07
– adjusted	0.19	0.67	1.38	0.10	0.39	0.87
In body fat						
– early in lactation	0.17	0.41	0.61	0.16	0.35	0.63
– late in lactation	0.08	0.28	0.74	0.09	0.24	0.44
– just after calving	0.11	0.38	0.82	0.12	0.37	0.80

heptachlor in milk fat were below the detection limits of 0.01 mg/kg fat. Contents of β-heptachlorepoxide just after calving were below 0.1 mg/kg, even for the highest dosage (Table 3). The contents of β-HCH and dieldrin in milk fat showed a similar trend as for cows in late and early lactation (Vreman et al., 1976), in that the contents decreased with time after dosing with pesticides was discontinued. In Table 2, the contents of β-HCH and dieldrin in milk fat immediately after parturition as found in this trial are compared with contents for cows early and late in lactation as found as in the earlier trials.

The values after parturition do not represent only the effect of dosing during the dry period, because the cows had also been dosed with pesticides late in lactation. As a result of this dosing, milk fat produced just before the start of the dry period contained β-HCH and dieldrin: for Group 1 an average background content in milk fat of 0.09 and 0.08 mg/kg, respectively, was found; 0.28 and 0.21 mg/kg for Group 2, and 0.48 and 0.39 mg/kg for Group 3. As found in a trial still to be published (Vreman & Poortvliet), the contents of these pesticides in milk fat just after calving were half of those in milk fat at the end of the preceding lactation. To find the effect of dosing with pesticides during the dry period, the values given in Table 2 should be adjusted by half of the background contents at the end of the preceding lactation (Table 2). A fairly good agreement was found between adjusted values just after calving and values for cows early and late in lactation, both at the end of the dosing period. In both trials, the total doses of pesticides were of the same order.

In the first weeks of lactation, the pesticide content of milk fat of cows in Groups 2 and 3 declined rapidly. The content of β-HCH in milk fat was halved within about 2 weeks. For Group 1, the rate of decline of β-HCH was much slower. For this group, halving of the initial value took about 4 weeks.

The rate of decline for dieldrin was slower than that for β-HCH. The value was halved after 3 weeks for the Groups 2 and 3 and after about 5 weeks for Group 1. This slower decline at a lower dosage was found also for DDT (Whiting et al., 1973).

After the first 2-3 weeks, the reduction in pesticide content slowed down and the time taken for a further halving was roughly double.

Body fat

Contents of β-HCH and dieldrin in body fat are presented in Fig. 3 and 4. Contents of β-HCH in body fat near parturition were always less than in milk fat. A considerable variation in pesticide content of body fat was found, particularly for dieldrin in cows with the highest dosage. The dieldrin contents 5 weeks later were hardly different for any group. The β-HCH contents tended to decrease only after the highest dosage.

Derivation of maximum tolerable content of pesticide in feed in the dry period

The daily administered dosages of pesticides used in our trial can be expressed as contents in the whole ration, as given in Table 1. These contents can be used to calculate an accumulation coefficient, i.e. the pesticide content in milk fat just after calving divided by the pesticide content in the feed of the dry period. The highest accumulation coefficients for the Groups 1, 2 and 3 are for β-HCH 3.78, 6.39 and 6.84, respectively, and for dieldrin 1.80, 4.14 and 4.41 (Table 3).

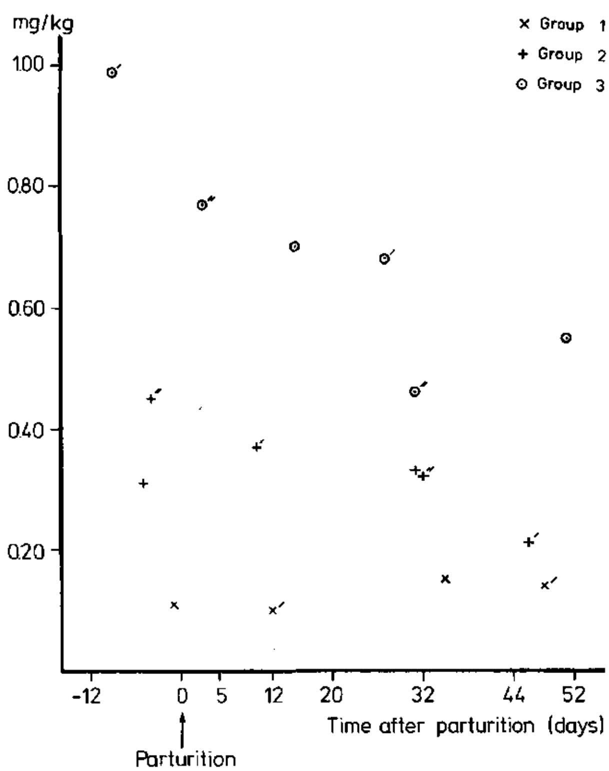

Fig. 3. Content of β-HCH in body fat of cows given three levels.

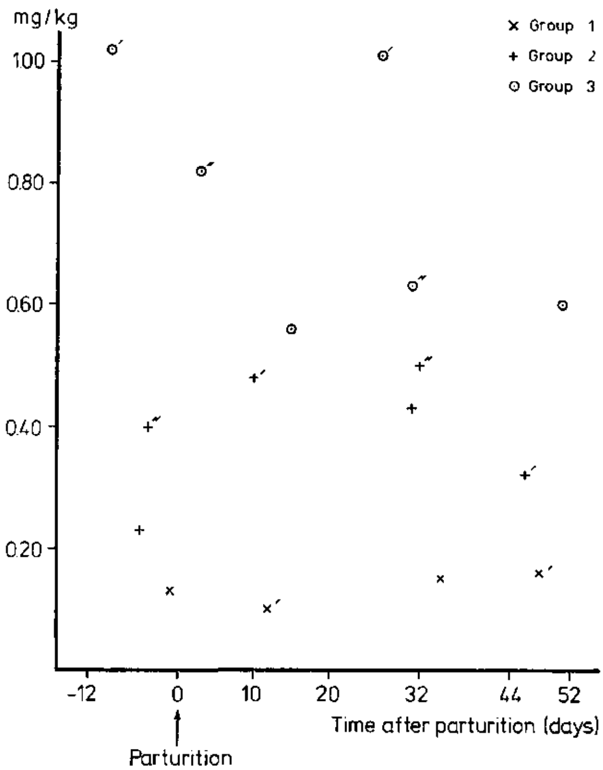

Fig. 4. Content of dieldrin in body fat of cows given three levels.

In Table 3 are also given the calculated transfer coefficients, defined as the proportion of oral pesticide intake per cow per day recovered per day in milk at the end of the dosing period, in this case just after parturition. These transfer coefficients are considerably higher than those found in earlier trials for cows early in lactation (Vreman et al., 1976).

The transfer coefficients for β-HCH and dieldrin of cows of Group 1 are about half of those of cows in Group 2. This result cannot be explained, but may be due to scatter.

The differences between cows within a group are considerable and largely due to variation in milk fat production and in length of the dosing period.

The maximum tolerable pesticide content in the daily ration can also be derived from the maximum tolerable pesticide content in milk fat by using the formula given in Part 1 (Vreman et al., 1976).

The results of using both types of coefficients are summarized in Table 4 and agree very well. The values for Group 1 are higher, because of lower accumulation coefficient and transfer coefficient (Table 3).

If we use other safety factors than 2, the maximum tolerable content of pesticide in the ration has to be changed accordingly.

Table 3. Average daily yield of milk fat; highest contents of pesticides or their metabolites in milk fat immediately after calving; calculated transfer and accumulation coefficients.

Group	Cow No	Average daily fat yield (g)	Content in milk fat (mg/kg)*			Transfer coefficients (%)			Accumulation coefficients		
			β-HCH	β-hepo	dieldrin	β-HCH	heptachlor	aldrin	β-HCH	heptachlor	aldrin
1	1*	—	—	—	—	—	—	—	—	—	—
	46	1100	0.21	0.021	0.10	46.2	4.6	22.0	3.78	0.38	1.62
	67	1040	0.16	0.050	0.10	33.3	10.4	20.8	2.88	0.90	1.80
Average		1070	0.19	0.036	0.10	40.7	7.7	21.4	3.42	0.65	1.80
2	25	976	0.65	0.029	0.39	63.4	2.8	38.1	5.85	0.26	3.42
	26	1243	0.71	0.038	0.33	88.3	4.7	41.0	6.39	0.34	2.97
	57	1153	0.66	0.046	0.46	76.1	5.3	53.0	5.94	0.41	4.14
Average		1124	0.67	0.038	0.39	75.3	4.3	43.8	6.03	0.34	3.51
3	16	783	1.52	0.055	0.93	59.5	2.2	36.4	6.84	0.25	4.19
	84	847	1.40	0.094	0.98	59.3	4.0	41.5	6.30	0.42	4.41
	96	910	1.20	0.100	0.71	54.6	4.6	32.3	5.40	0.45	3.20
Average		847	1.38	0.083	0.87	58.4	3.5	36.8	6.21	0.37	3.92

* Net values, obtained by subtracting the background pesticide content from the analytical results; see text.

** Cow number 1 did not calve during the investigation.

Table 4. Maximum tolerable pesticide content* in the daily ration (mg/kg) derived** from tolerances in milk fat.

Pesticide	Type of calculation	Group			Tolerances	
		1	2	3	milk	feed
β-HCH	accumulation coeff.	0.007	0.004	0.004	0.05**	0.02
	transfer coeff.	0.006	0.004	0.003		
Aldrin	accumulation coeff.	0.042	0.018	0.017	0.15	0.02
	transfer coeff.	0.038	0.016	0.015		
Heptachlor	accumulation coeff.	0.083	0.181	0.167	0.15	0.03
	transfer coeff.	0.075	0.163	0.148		

* Adjusted to 12% moisture.

** Derived by using the highest accumulation and transfer coefficient for each group of 3 cows and by using a safety factor of 2.

*** Used by the authors as an example for calculation.

The result for aldrin is in agreement with regulations from the Board for Animal Feedingstuffs (Produktschap voor Veevoeder, last column), the result for heptachlor is higher than the maximum tolerable content given by the Board. Heptachlor can be converted to β-heptachlorepoxide. The transfer for this metabolite from feed into milk is much higher than for heptachlor itself. A transfer coefficient as high as 39.6 has been reported (Hascoet, 1970) for the epoxide. This high transfer coefficient for β-heptachlorepoxide leads to a maximum tolerable content in the ration of about 0.01 mg/kg. The regulations from the Produktschap voor Veevoeder do not list a tolerance for β-HCH in the feed. The Council of the European Communities (EEC doc 903/VI/75) has proposed a provisional maximum content for single feedstuffs of 0.02 mg/kg, which is much higher than the calculated value given in Table 4.

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